

EL2310 : Matlab Project

Simulate, visualize, and predict WiFi signal strength in a free space

Objectives:

Create a Matlab function that accepts several input arguments and simulates a free space WiFi signal strength.

Visualize the created data with a dynamic movie (and plot)

Extract the parameters given a sample signal strength data

Mathematics:

Use the formula below to calculate the signal strength S at each point in space.

$$S = P_t + C - 10 n \log(|d|) + X \quad (1)$$

Where, P_t is the transmit power of the Access Point,

C is the channel gain. $C = G_t + G_r + 20 \log(v/(4\pi f))$ with G_t being the transmit antenna gain, G_r being the receive antenna gain, v being the velocity of light and f being the frequency of the WiFi signal used (typically 2.4 GHz but can also be 5.2GHz),

n is the environmental parameter that represent the loss exponent (usually 2 to 6),

d is the Euclidean distance between the point (where the strength is measured) and the Access Point/AP (signal source) location,

$X \sim N(0, \sigma)$ is a Gaussian random variable with zero mean and standard deviation σ depending on the environment. σ usually ranges between 2 to 8.

Note 1: $\log$ is the base to 10 ($\log_{10}$) and not the natural logarithm.

Note 2: At the AP location, $S = P_t$

Note 3: If $0 < |d| \leq 1$, then $S = P_t + C$

Note 4: All units (for S , P_t , C , and σ) are in dBm.

Expected solution:

I. A Matlab function with the following definition

Wifi_simulator (map_size, AP_location, signal_params, environment_params, options)

Where the inputs are,

$\text{map_size} = [x_min, x_max, y_min, y_max, \text{resolution}]$

AP_location = [AP_x, AP_y]

signal_params = [Pt, Gt, Gr, frequency]

environment_params = [n, sigma]

Optional parameters (options):

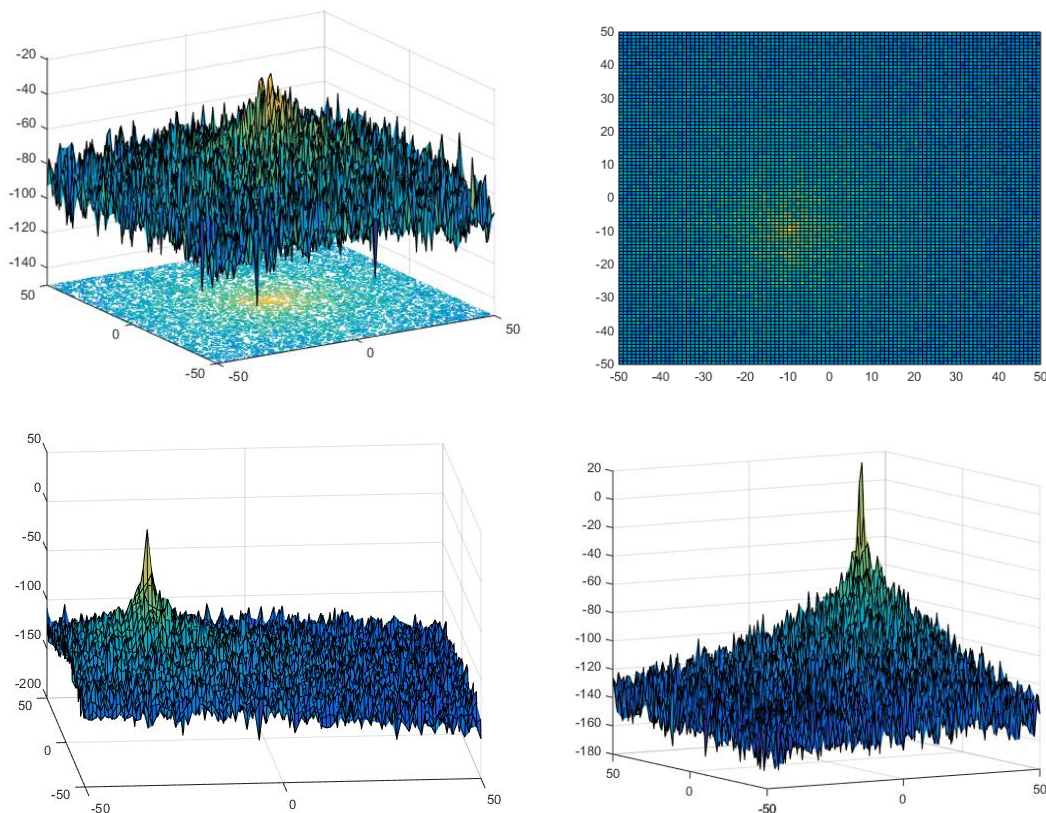
1. arg: 'output', values: 'plot' or 'movie' – a simple surf plot or a surf plot movie for 10 seconds
2. arg: 'movie type', values = 'AP' or 'temporal' – this option is for the movie output. AP means show the movie with the AP location moving linearly (on any axis) from the given location. Temporal means show the movie with a new random sequence in each frame for the X variable so that the movie shows the dynamic nature of the changes in the WiFi signal strength.

Set the options 'output' and 'movie type' as 'movie' and 'temporal' by default respectively.

Output:

1. A plot or a 10 second movie as per the option passed
2. Save the variables x, y, S, n in "wifidata.mat". Generate 10 datasets with different arbitrary parameters and call them "wifidata_x.mat" with x=1:10.

Expected (Sample) plot outputs:



Expected (sample) movie output: <http://www.csc.kth.se/~ramviyas/wifimovie.avi>

II. A Matlab script to predict the WiFi signal model given a dataset

Clear all your workspace variables before executing this function.

Load the datasets you saved in the previous function (wifidata_x.mat) one by one.

1. Create a subplot figure with size [1, 2] and surface plot the loaded data in the first subplot.

2. Fit a simpler version of the signal strength formula

$$S = C1 - 10 n \log (|d|) \quad (2)$$

Note 1: use any fitting function to find a solution for the parameters C1 and n.

Note 2: you cannot assume that you know the AP location.

3. Check if the predicted parameter n is close to the ones you used to create the data.
Print the error in the predicted n value.

4. Now calculate S with the fitted parameters for the same x and y values using eqn. (2).

5. Plot the predicted signal strength in the second subplot that you created.

Repeat steps 1-5 for every dataset and plot the errors of the predicted n values from all the 10 datasets. Calculate the Root Mean Squared Error (RMSE) and print it.

Try to reduce the RMSE as much as possible.